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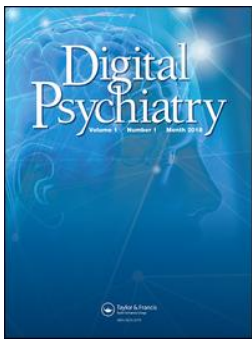
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ARTICLE

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Internet-connected devices ownership, use and interests in bipolar disorder: from desktop to mobile mental health

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ABSTRACT

Advances in communication technologies have led to a new era of ubiquitous accessibility to Internet-based platforms (IBPs) and devices with an unprecedented potential for mental health. However, it is rarely explored if potential user groups own devices from which they can access these or whether they are interested in the development of new platforms. Two anonymous surveys were circulated to 20,000 subscribers of the Bipolar UK e-newsletter. A total of 570 people responded to the first survey and 286 responded to the second. The first contained five questions regarding participants' interest in a smartphone IBP to support their illness while the second consisted in 27 questions exploring devices ownership and use as well as their potential interest in emerging new IBPs: 97.6% of respondents were diagnosed with bipolar disorder (BD) by a healthcare professional and 92.8% of them owned a smartphone. The most frequent purposes for daily smartphone use were text messaging (73.4%), e-mail (71.3%) and social networks (53.8%). About 77% of respondents expressed willingness to receive self-management strategies through a smartphone app. The pattern of widespread and growing ownership and use of devices with access to IBPs among people with BD is similar to that of the general population. Combined with the expressed interest in novel technological developments for disorder self-management, this represents a great opportunity to establish a two-way avenue to collect and deliver novel type of interventions offering personalized material to people with BD.

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Introduction

The continuous advances in digital technology and communications have led to a new era of seemingly ubiquitous accessibility to Internet-based platforms (IBP) and devices with an unprecedented potential for mental health. Given the opportunities that these platforms open for illness management and treatment, there is a need to investigate the Internet use patterns of people suffering from mental illnesses. In this context, Kalckreuth et al. reported that among 337 service users of the Department of Psychiatry of the University Hospital Leipzig in Germany, almost 79.5% were internet users and the most common use was information seeking [1]. Similarly, in a more heterogeneous international sample of people suffering from BD, Bauer et al. found that 81% were regular Internet users and almost 78% used the Internet to seek information about their condition [2]. These usage percentages closely resemble those found in the general population of developed countries [3]. Further, the factors related to limited Internet access

and use among people with mental health disorders are similar to those found in the general population (i.e. age, education, local infrastructure).

A key factor contributing to the exponential growth of Internet access in recent years has been the wide-spread availability of mobile devices. These relatively new technologies (such as smartphones and wearables) have the technical capabilities to continuously collect both active and passive granular information about user behaviour [4,5]. Several studies have already demonstrated the potential for diagnosing and capturing illness activity in BD based on smartphones use patterns [6]. Additionally, these technologies open a two-way avenue to collect a novel type of comprehensive illness-relevant data while simultaneously delivering personalized mental health interventions remotely, at a low cost and on a large scale [7] (Figure 1). Several apps and IBPs have now been developed to deliver psychological interventions. At this stage, however, few of them have been appropriately validated in terms of safety

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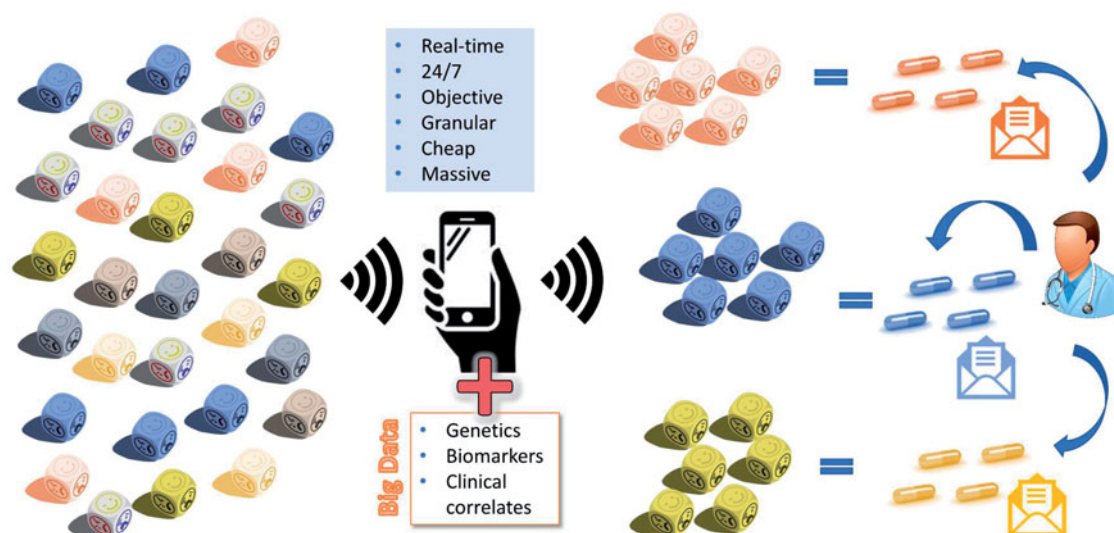


Figure 1. Mobile mental health: key factor on the route towards personalized psychiatry. The process and potential by which smartphones could become a game-changing factor on the route towards personalized psychiatry when combined with other types of data: collecting continuous usage patterns from smartphones might allow us to identify digital phenotypes which when merged with genetics, biomarkers, clinical correlates and other data sources could lead to better characterization of specific subgroups of people who might benefit from specific treatments.

and efficacy [8,9]. Further, very few of these have actually explored the smartphone/Internet use patterns of their target population.

One of the few studies reporting on smartphone ownership and use among mental health patients, Torous et al. reported that 72% owned a smartphone and almost half were interested in using mobile applications [10]. More recently, a cross-sectional meta-analysis by the same group found a 66% smartphone ownership among people suffering from mental illnesses as well as a high acceptability of these new technologies [11]. To our knowledge, no similar data have been published for people with bipolar disorder (BD).

In this study, we explored and characterized smartphone device ownership and use patterns, as well as interest in novel technologies, among people with BD by approaching a community of subscribers to an e-newsletter from a national charity supporting people suffering from BD and their caregivers (Bipolar UK).

Methods

Invitations to complete two different anonymous online surveys were included within the contents of two successive Bipolar UK e-newsletters circulated by e-mail to more than 20,000 subscribers. The first survey was focused on the interest of people with BD in using a smartphone app as a support tool for their illness and consisted of five Likert-scale questions in addition to the possibility of adding comments in each item. The second survey was more comprehensive and contained 27 multiple choice questions regarding device ownership, usage

patterns and interest in further new Internet-based technologies. No previous knowledge of novel technology was assumed, and additional information/definitions were provided for potentially unfamiliar concepts such as chatbots, wearables and virtual reality. Sociodemographic and self-report diagnosis data were also collected. The first survey was active between 01/07 and 09/07/2018 and the second survey between 08/10 and 29/10/2018.

As no mandatory response to any specific question was requested, this resulted in a variable number of responses for each item. Hence, each question was independently treated to characterize the sample. As an overlap between the populations of the two surveys could not be assumed, correlations between answers were only explored within the same survey. Normality tests were performed for all continuous variables and the appropriate parametric and non-parametric tests used accordingly. A binary logistic regression was conducted to evaluate the effects of sociodemographic variables on owning a smartphone and interest in new emerging platforms. Statistical significance was established at $p < .05$. Data were analysed using SPSS version 25 (SPSS Inc., Chicago, IL).

Results

Survey 1: Interest in specific features of a potential smartphone app to support the self-management of bipolar disorder

Of the 570 people who took part in this separate survey, 77% of respondents strongly agreed or agreed that they would be willing to receive self-management strategies and/or psychoeducational

advices through a smartphone application. In this context, 81% responded that they found the idea of tracking their daily mood by completing a brief questionnaire on their smartphones appealing, while 63% found the possibility of having their mood monitored automatically based on their apps' usage patterns interesting. Seventy-one per cent were interested in tracking their mood with wearables. Finally, 73% agreed or strongly agreed that using a combination of questionnaires and app usage-patterns to prompt more personalized advice and guidance would be the most helpful and an acceptable support tool. Some interesting comments among those who found attractive the idea were 'An app is a great idea, especially if people are unwell and not capable of going on a computer – a phone is much easier'; 'I feel using smartphone apps would be a very effective way of keeping a detailed record of changes and any correlation between device usage, sleep, etc. as long as the recorded data was accurate' and 'I think there's massive room for use of pocket technology in improving our own self-management. It needs to be visually appealing and preferably with simple data inputting and different levels of analysis available if I'm going to maintain interest long term'. On

the other hand, some noteworthy comments left by those who didn't find this idea interesting were 'I prefer contact with a person. Also when I'm feeling low a symptom is to avoid my phone, computer (communication) so I think I'd struggle to access this information or avoid/reject it.'; 'Automatic collection of data, while offering potential for greater accuracy, offer too high a risk of intrusion and data loss.'; and 'I am not sure this is something I would use. I have a very busy life and deal with my bipolar very pragmatically monitoring my own sleep and meds. This smartphone system doesn't sound like a good fit'.

Survey 2: Sociodemographic information, device ownership, usage patterns and general interest in new Internet-based technologies

The average age of the sample was 46.3 years ($SD=11.4$) with a predominance of females (70%, $N=198$). Regarding income, there was a clear preponderance of low income ($\leq £10,000$ – $£20,000$) (43.7%) in comparison to medium ($£20,001$ – $£40,000$) (29.9%) and high ($\geq £40,000$) (26.3%). In terms of education, a significant proportion of the sample ($N=286$) reported having completed a post-

Table 1. Sociodemographic and illness variables.

	<i>N</i>	Mean	SD
Age	274	46.3	11.4
	<i>N</i>	Median	IQR
Years since formal diagnosis	272	9	13
	<i>N</i>	Valid percentage	
Gender			
Female	198	70	
Male	83	29.3	
Ethnicity			
Asian or Asian British	6	2.1	
Black or Black British	4	1.4	
Mixed	7	2.4	
White	262	91.6	
Other	7	2.4	
Income			
Below £10,000	51	18.1	
£10,001–£20,000	72	25.6	
£20,001–£30,000	45	16	
£30,001–£40,000	39	13.9	
Above £40,001	74	26.3	
Education			
No qualification	9	3.1	
Secondary education	26	9.1	
Post-secondary education	53	18.5	
Vocational qualification	36	12.6	
Undergraduate degree	100	35	
Post-graduate degree	61	21.3	
Current disability	240	84.2	
Disability nature			
A learning difficulty	4	1.4	
A long-standing psychological or mental health condition	176	61.5	
Other (including any long-standing illness)	4	1.4	
More than one	66	23.1	
Disabling disability	218	77	
Current specific pharmacological treatment for BD	267	93.7	
Current specific psychological treatment for BD	78	27.4	

BD: bipolar disorder; IQR: interquartile range; SD: standard deviation.

graduate (21.3%) or undergraduate (35%) degree. The complete sociodemographic data are detailed in Table 1.

Almost all participants (97.6%) reported being diagnosed with BD by a healthcare professional while the remainder thought they were suffering from the disorder. The median years since formal diagnosis were 9 (IQR = 13). Ninety-three per cent replied that they were receiving pharmacologic treatment at the time of the survey and only 27.4% were receiving an adjunctive psychological treatment. A vast majority of the sample ($N = 285$) answered that they had at least one disability (84.2%) being the most common cause a long-standing psychological or mental health condition (61.5%).

Only 29% ($N = 83$) of participants stated that they owned a desktop computer and 67.8% ($N = 194$) owned a laptop computer. Regarding mobile devices, 194 (67.8%) of respondents answered that they owned a tablet and 258 (91.8%) owned some kind of mobile phone. Of those owning a mobile device, 258 (92.8%) owned a smartphone whereas 20 (7.2%) had a feature mobile phone (i.e. a mobile phone with calls and text messaging capabilities but with limited internet access and advanced functionalities). The median time of smartphone ownership was 8 years (IQR = 5). The most frequent smartphone operating system (OS) owned by participants was Google's Android (50.3%, $N = 144$), followed by Apple's iOS (39.9%, $N = 114$). Twenty-seven participants selected the options 'other' or 'don't know'.

A logistic regression was performed to ascertain the effects of age, education, gender and income on the likelihood that participants owned a smartphone. The logistic regression model was statistically significant, $\chi^2(5) = 28.605$, $p < .0001$. The model explained 23.0% (Nagelkerke R^2) of the variance in smartphone ownership and correctly classified 91.0% of cases. A higher education and a younger age were the only two variables increasing the likelihood of owning a smartphone.

The most frequent daily purposes for smartphone use were text messaging (73.4%), e-mails (71.3%) and using social networks (53.8%); less frequent were watching videos (15%), reading books (12.6%) and video-calling (12.2%) (Figure 2). There was a significant percentage of respondents who stated they have used at least one app related to their mental health in the past (56.5%, $N = 152$) but less than half of them were still using one (34.9%, $N = 94$).

Out of the 278 subjects who responded about wearables (i.e. smartbands and smartwatches) ownership and use, 164 (59%) never owned one, 73 (26.3%) owned and were currently using one and 41 (14.7%) previously owned one but were no longer using it. About 50% were using them to track fitness activities and almost 40% to monitor sleep time or quality. The main reasons given for stopping to use wearables were the following: not finding it useful (19%), it was uncomfortable to wear (5.2%), it was inconvenient/difficult to remember charging it regularly (11.9%), and not trusted in the information collected by the devices (3%). The majority (82.3%, $N = 191$) stated they would be interested in a wearable in the future if it provided relevant information for their mental health.

Lastly, regarding the potential application of specific new modalities of IBPs as a support tool, self-management and/or care of their condition: 65% ($N = 182$) were interested in psychiatric or psychological consultations/interventions through videoconference (VC) platforms, 45.7% ($N = 128$) were interested in implementation of chatbots and 52.5% ($N = 147$) stated they might be interested in virtual reality-based (VR) platforms to assist or support their mental health. There were a noteworthy percentage of respondents (14.3% for VC, 12.5% for chatbots, 12.1% for VR) clarifying that their interest in the use of these new technologies may be dependent on several key factors, including their mood state, confidentiality and the fact that they were not going to

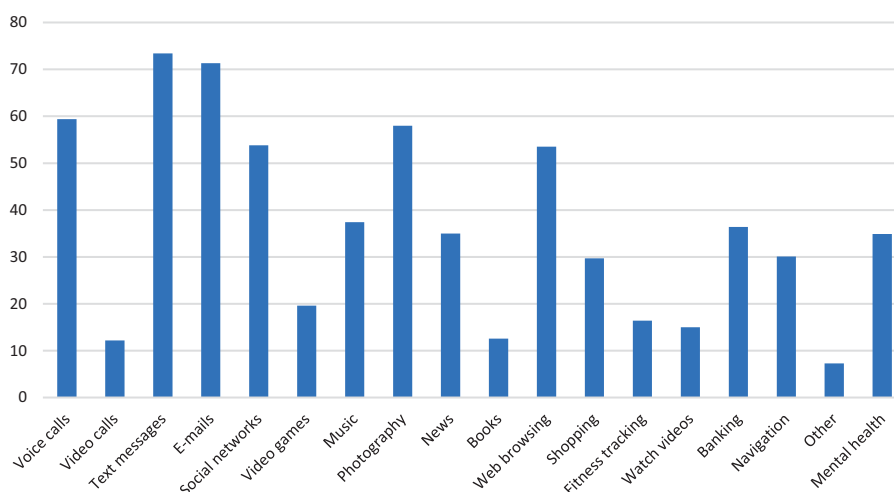


Figure 2. Percentages of the most frequent smartphone uses reported by survey respondents.

be used as a replacement of, but only in addition to, traditional face-to-face therapies. After conducting logistic regressions, younger age and male participants were significantly associated with an increased interest in VC and chatbots. Income level or ethnicity did not seem to have an effect on the interest in any of these new technologies. Other details about ownership, uses and interest in new Internet based technologies can be found in Table 2.

Discussion

The results of this study confirm that the ownership and use of Internet-based technologies and devices among people with BD resembles those of the general population. It is also interesting to note the same transition pattern from desktop computers to mobile devices which has been seen globally in recent years [12,13]. The results of this study reflect the increasing interest among people with BD in using new technologies to receive information about their disorder and personalized support and treatment. Bauer et al. reported similar percentages of internet use in BD patients compared to the general population [2], with over three quarters using the Internet to seek support resources for their condition.

The percentage of people reporting owning a smartphone in our study (91.8%) is higher than the global general population rates reported 2 years ago [14]. These figures are also higher than those reported previously across different mental health populations, for example, 62.5% in a general psychiatric population [15] and 49% in a psychosis population [11]. Most recently, a smartphone ownership rate of 90.2% was reported among patients of a private outpatient clinic for mood and anxiety disorders [16]. This exponential growth may be explained with the constantly reducing costs of technology, which allow for increased access among lower income populations, as has been noted in the general population [17]. This may have also been the case in our sample, as there were no significant differences in ownership across income level groups, despite 43% of respondents reporting having low income. The only sociodemographic or clinical variables influencing smartphone ownership were age and education.

Regarding the most frequent reasons for smartphone use, our results are in line with the general population, namely texting, e-mails, social networks and photography [18]. Similar patterns have been noted among people suffering from mental illnesses, with texting and social networking being the most frequent uses in a sample of community mental health centres [19].

In addition to smartphones, our study noted a high percentage of wearable devices ownership

Table 2. Ownership, uses and interest in new Internet-based technologies.

	N	Valid percentage
Ownership		
Desktop computers	83	29
Laptop computers	194	67.8
Tablets	194	67.8
Mobile phones	278	97.2
<i>Feature phone</i>	20	7.2
<i>Smartphone</i>	258	92.8
Android	144	50.3
iOS	114	39.9
Wearables (e.g. smartwatches, smartbands, etc.)	114	41
Uses		
Smartphone		
<i>Voice calls</i>	170	59.4
<i>Video calls</i>	35	12.2
<i>Text messages</i>	210	73.4
<i>E-mails</i>	204	71.3
<i>Social networks</i>	154	53.8
<i>Video games</i>	56	19.6
<i>Music</i>	107	37.4
<i>Photography</i>	166	58.0
<i>News</i>	100	35.0
<i>Books</i>	36	12.6
<i>Web browsing</i>	153	53.5
<i>Shopping</i>	85	29.7
<i>Fitness tracking</i>	47	16.4
<i>Watch videos</i>	43	15.0
<i>Banking</i>	104	36.4
<i>Navigation</i>	86	30.1
<i>Other</i>	21	7.3
<i>Mental health</i>	94	34.9
Wearable		
<i>Fitness tracking</i>	111	50.5
<i>Sleep tracking</i>	84	39.3
Interests		
Videoconference assessments/treatments	182	65.0
Chatbots	128	45.7
Virtual reality assessments/treatments	147	52.5

among the BD population (41%). Given the vast amount of automatically generated data these can provide to monitor known risk factors for BD episodes such as sleep quantity and quality and physical activity, these findings suggest that there is already an infrastructure in place for personalized self-monitoring or intervention programmes. Further, we noted a significant interest among participants (82.3%) in exploring these possibilities further.

However, only 34.9% of participants in this study reported currently using mental health apps. A possible reason for this could be that despite the large availability of various mental health apps in app stores, the majority of these have not been scientifically validated for efficacy and acceptance. Several studies have demonstrated high rates of user acceptance and satisfaction when using properly tested mental health apps in research studies [8,20,21]. Therefore, there is a need to develop guidelines and frameworks to validate mental health apps in order to make them available to those who might benefit from them [7,9].

It is also worth noting that the OS distribution frequency in this study was almost equally split between Android and iOS. This is of significance for any app or platform intending to collect data and deliver mental health interventions through smartphones, as different OSs mean increases in

development costs and technical difficulties in ensuring uniformity across OS versions.

Our results show a high interest among people with BD in exploring the potential of new technologies such as virtual reality, videoconference and, to a lesser degree, chatbots to support the management of their condition. Rates of 60% or above have been reported across people with varying mental health diagnoses when interest in such technologies has been explored [10,11,16].

Psychological treatments have been demonstrated to improve the prognosis of many mental health conditions, including BD [22]. Considering the limitations of most health care systems in offering psychological treatments to everyone needing them, it is important to explore the potential of these novel Internet-based technologies in order to improve access to cost-efficient psychological treatments [23]. The interest in this was confirmed by participants' answers expressing a preference for a potential smartphone app delivering personalized advice as well as other emerging IBP technologies for their disorder self-management. However, they also highlight the need of adapt these IBPs to the specific service users' needs and validating them in terms of accuracy, safety, efficacy and confidentiality before making them available.

Limitations

There are several limitations that should be noted in this study. First, the online self-report nature of these surveys may have led to the inclusion of people with unconfirmed diagnoses. However, the illness and medication history reported by participants in these surveys closely resemble those of patient populations in clinical studies. Second, there is a selection bias related to inviting participants through a bipolar disorder charity e-newsletter, as this assumes, they were already using Internet-based technologies for the purposes of informing themselves about their disorder and might thus be more likely to be interested in using these in the future as well. No information was available about the people who did not respond to the survey invitation. Finally, an inherent limitation of this kind of cross-sectional studies is that it is not possible to establish causality.

Conclusion

The ownership and use of Internet-based devices is growing at a rapid rate among people with mental health conditions, with patterns like those of the general population. Our results demonstrate that there is a steadily growing interest among people with BD in exploring the potential of these new technologies for the management of their condition. The research community should attempt to make

use of the vast behavioural data available due to the wide-spread ownership of such devices and use it (in combination with other data sources) to better characterize psychiatric disorders phenotypes and develop personalized support tools and treatments.

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Disclosure statement

None of the authors have relevant conflicts of interest to declare.

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